GENERAL STATEMENT ON THE FUNCTIONING OF THE EOLE PROJECT

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GENERAL STATEMENT ON THE FUNCTIONING OF THE

"EOLE" PROJECT

1 - MISSION OF THE "EOLE" SATELLITE

In assocatation with a system of 500 constant ceiling balloons capable of drifting with the wind and thus playing the role of tracers of air masses, the role of the satellite is to interrogate and to localize the balloons.

Interesting physical parameters such as pressure and temperature, for example, are measured on board each balloon and transmitted to the satellite each time that the latter interrogates a balloon.

On board the satellite, a memory device permits the registration of all these physical quantities as well as geometric data and time. The whole of this information will be transmitted to the ground by the satellite, where, thanks to a mathematic analysis accomplished by a calculator, one will be able to restore the exact position of each balloon, as well as the physical parameters of pressure and temperature.

The EOLE satellite will be placed in orbit with the help of a SCOUT launcher leaving the base on Wallops Island. The orbit will be circular, of an altitude chosen between 800 and 1200 km and of inclination chosen between 40° and 50°. The choice of altitude and inclination will be made later.

The satellite-balloon and balloon-satellite connection system has as its goal:

- the call of a given balloon,
- the localization of the balloon called,
- the transfer of meteorological information from the balloon called to the satellite.

2 - CALL OF THE BALLOONS

2.1. Programmed functioning

Four situations are anticipated:

- A certain number of balloons are in the air. Their positions are unknown.
  One desires to contact all of them.
- A certain number of balloons are in the air. The position of some of them is known.
  One wishes to contact only these balloons.
- A certain number of balloons are in the air.
  One does not wish to contact them for a certain time but only to maintain their locked receiver and to maintain the bit synchronization.
- No balloon is visible from the satellite for a certain time.
  One desires to stop the functioning of one part of the satellite, notably the U.H.F. transmitter to limit the power consumed.

Solutions retained:

2.1.1. Sequential call

Some balloons have been launched, their positions are unknown. One desires, in this case, to call all the balloons continuously, one after the other in a certain order, for a certain time.

The solution retained is the following:

- the sequential call program contains:
  . the address of a balloon i which is beginning its sequence,

. the hour of the beginning of call,

. the hour of the end of call.

The balloons from i to the 511 are called in an unchangeable order. This order is that defined by a binary sequence, cyclic, available on board the satellite, permitting at the maximum the call of 511 balloons (see figure 1).

i is determined in such a way that the desired balloons are called in the course of the partial unfolding of the sequence from i to 511.

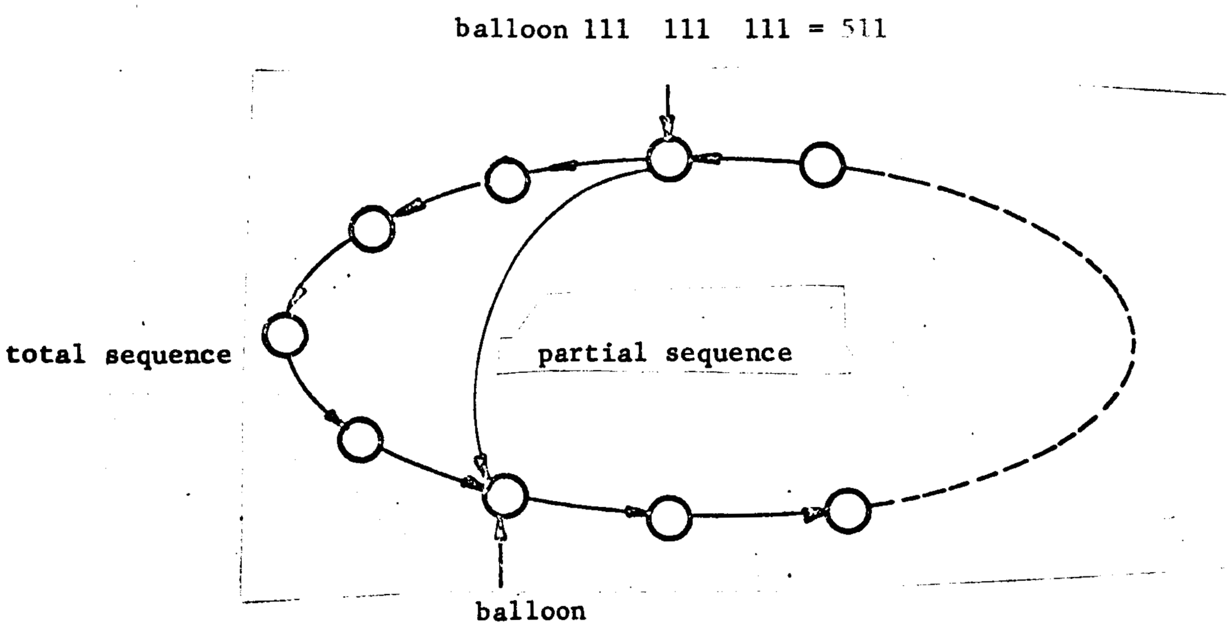


Figure number 1

SEQUENTIAL CALL

2.1.2 Non sequential call

Some balloons have been launched. The position of some is roughly known.

One desires to contact only these balloons.

The following solution is retained:

- The maximum number of balloons whose interrogation can be programmed is 64.
- Each of the programmed balloons is interrogated every 40 seconds for 320 seconds (or 8 times).

The call program contains:

- the names of the balloons to be interrogated,
- the definite hour of beginning call at 320 seconds.

The repitition of the call is made automatically on board the satellite.

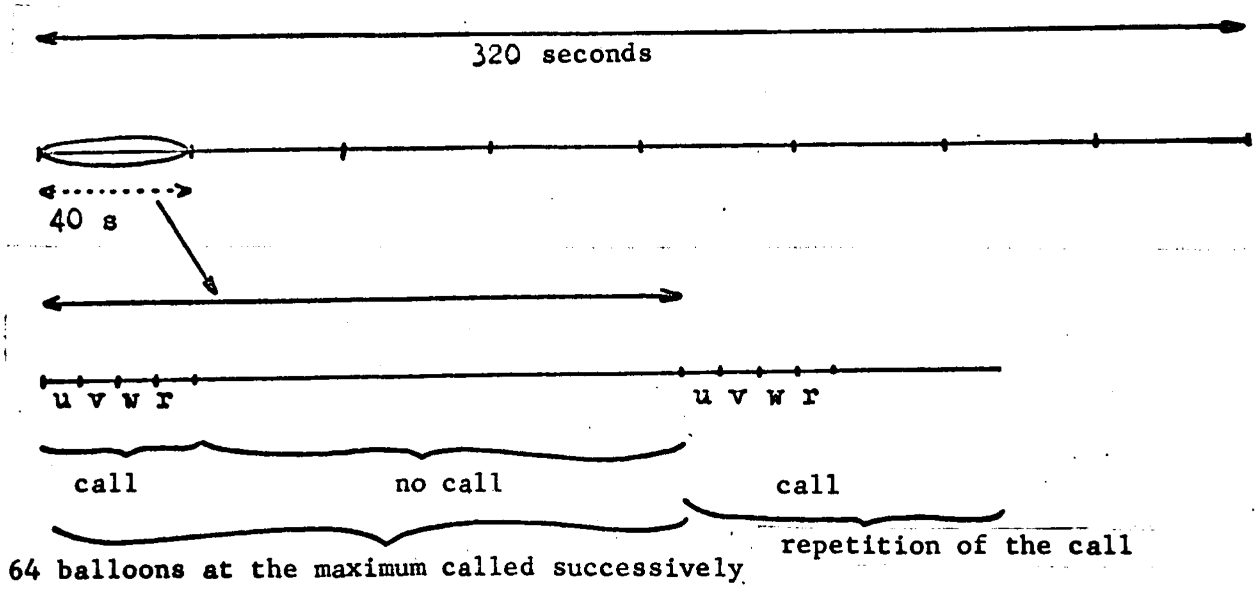


Figure number 2 - NON SEQUENTIAL CALL

Example of 4 programmed balloons

During the time which elapses between the call of the last of the programmed balloons and the repetition of the call, the satellite broadcasts a signal which maintains locked the receivers and the system of bit reconstitution of the balloons. The satellite functions in synchronization call as described below.

2.1.3. Synchronization call

This call consists in the sending of a signal permitting the balloons in sight to lock, or to maintain their receiver and their bit reconstitution system locked.

This signal is produced systematically during the moments which elapse between the calls of the balloons. The sending of the signal is not programmed.

2.1.4. Stop - Operation

No balloon is in view of the satellite during a known time lapse. One wishes in this case to stop a part of the satellite equipment to economize on power. In this case and in this case only the U.H.F. satellite transmitter is stopped.

Solution retained:

One programs the stop time,

the time of return to operation.

2.2. Non programmed function

By telecommand, one can also:

- stop in actual time a part of the satellite equipment, notably the U.H.F. transmitter

- return to operation in actual time all the satellite equipment in the configuration: sequential call of the 511 balloons.

2.3. Call message of a balloon

The call message of a balloon is a binary sequence of 30 bits organized in three words, in the order:

- one word of 18 bits,
- one word of 6 identical bits,
- one word, complementary to the preceeding word, of 6 identical bits.

The bit cadence is 48 bits per second.

The duration of a message is 0.625 seconds.

2.3.1. Word of 18 bits, or word 18 "PN"

2.3.1.1. Generation

A nine stage divergence register, returned to itself by the "addition module 2" operation on stages 5 and 9, produces a repetitive sequence of 511 bits in length (PN sequence).

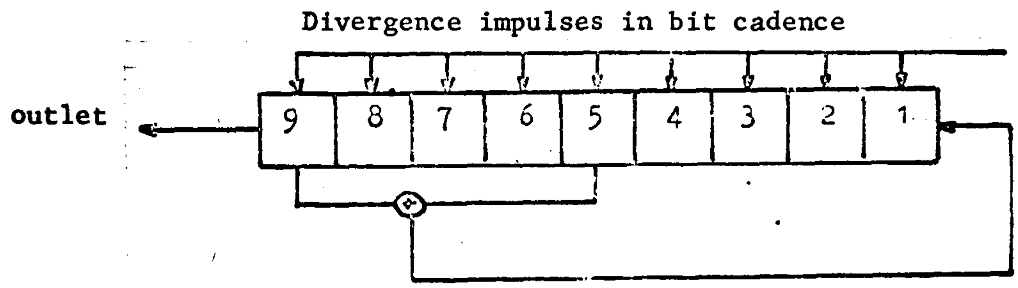


Figure number 3

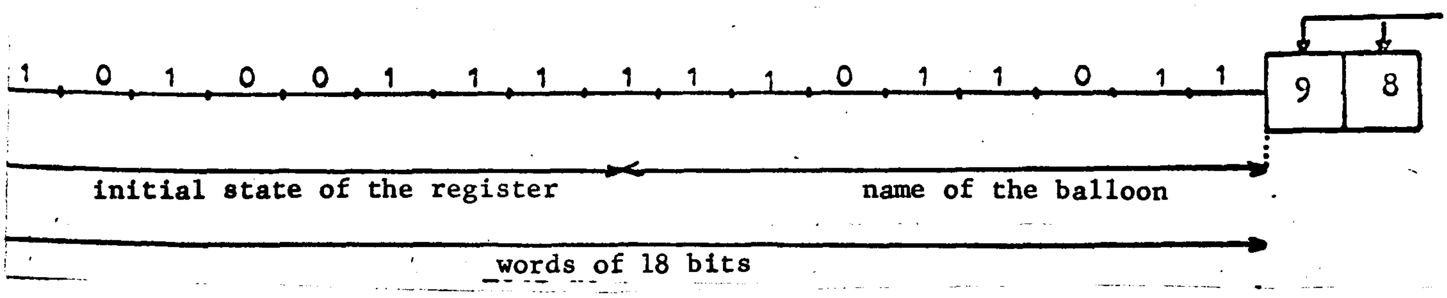
If one considers the binary numbers of 9 bits contained between two successive divergences in the register, one shows that all the numbers, from 1 to 2 to the ninth minus 1 (2^9-1), (= 511) appear. Each one of them appears once and once only in the sequence.

2.3.1.2. Utilization

In considering the words grouping 18 bits leaving the register one defines 511 different words.

It is sufficient to charge the register by the first 9 bits of a word to produce the following 9 without ambiguity.

One calls "address" or "name of balloon" the binary number (or its decimal equivalent) represented by the last 9 bits of the word of 18 bits assigned to each balloon.



2.3.2. Words of 6 bits

It concerns 6 "0" words and 6 "1" words.

2.4. Role of the call message

The call message of a balloon has as its role:

2.4.1. Permitting the call balloon to be recognized

2.4.2. Sending to the balloon called one of the two orders:

- operate,
- destruction.

Call message OPERATE	18 PN - 6 "0" - 6 "1"
Call message DESTRUCTION	18 PN - 6 "1" - 6 "0"

Figure number 5

Composition of the call messages

2.5. Synchronization message

This message is produced systematically during the moments which elapse between the calls of the balloons. Its composition is given in figure number 6.

SYNCHRONIZATION message	18 "0" - 6 "0" - 6 "1"

Figure number 6

2.6. Call program

2.6.1. The call program is made up of instructions

Each instruction indicates the function to be accomplished.

The maximum number of instructions capable of being stocked is 64. Each instruction contains 22 bits and is organized according to the rigid format below:

9 bits	9 bits	4 bits
time	initial state	order

Figure number 7 Format of instructions

2.6.1.1. Time

The moment of execution is programmed by a word of 9 bits defining the time at about 320 seconds, in a total duration of 163 840 seconds (45 h 30 mn 30 s).

2.6.1.2 Initial state

A word of 9 bits. These are the first 9 bits of the word 18 PN corresponding to the desired balloon.

It is sufficient to load these 9 bits in the 9 stage returned register by the module 2 addition operation on stages 5 and 9, to produce the 18 PN word whose last 9 bits represent the address of the desired balloon.

2.6.1.3. Order

A word of 4 bits. This word is the order which indicates to the call coder the operation to be accomplished:

- OPERATION sequential call
- DESTRUCTION sequential call
- end of sequential call
- OPERATION non sequential call
- DESTRUCTION non sequential call
- stoppage of the satellite equipment
- operation of the satellite equipment

2.6.2. Content of the program

Two cases are possible:

2.6.2.1. Case A: command by two successive instructions

Departure instruction	time of beginning	9 i bits	sequential or stop call
End instruction	hour of end	9 i bits	sequential or operation end

Figure number 8

Case A

The 9 i bits correspond to the initial state of the register beginning with which the sequential call should take place.

2.6.2.2. Case B: command by an instruction

This case concerns the non sequential call.

time	9 i bits	non sequential order

Figure number 9

Case B

The repetition of the call of the balloon corresponding to the 9 i bits every 40 seconds for 320 seconds is obtained by rereading eight times the same instruction.

2.6.2.3. The program contains 64 instructions at the most

Certain instructions (corresponding to case A) are necessarily grouped by two's. Others (corresponding to case B) are independent.

Instruction No.	time 9 bits	Initial state 9 bits	Order 4 bits
1	t_1	i	S N
2	t_2	i	S F
3	t_3	j	N S M
4	t_3	k	N S M
5	t_3	l	N S M
6	t_3	m	N S M
7	t_4	r	N S D
8	t_4	s	N S D
9	t_5	w	S D
10	t_6	w	S F
11	t_7	a	A
12	t_8	a	M

<u>Figure number 10 - Example of the program</u>

<u>Program of 12 instructions</u>

<u>Legend</u>:

S M: beginning of the sequential call OPERATION

S D: beginning of the sequential call DESTRUCTION

S F: end of sequential call

N S M: non sequential call OPERATION

N S D: non sequential call DESTRUCTION

A: stop

M: operation

3 - LOCALIZATION

3.1. General principle (see figure 11)

The solution retained is the following:

One measures, on board the satellite, two parameters:

- the angle "Θ" between the speed vector "$\vec{V}$" of the satellite and the satellite-balloon direction,
- the satellite-balloon distance "d".

The measure of the angle "Θ" (or Doppler measure) defines a first geometric place: cone of which the satellite is a summit and Θ the half-angle of opening.

The measure of distance "d" (or distance measure) defines a second geometric place: a sphere of which the satellite is the center and "d" the radius.

One recognizes a third place: the "sphere of the balloons" concentric to the land sphere and the radius $R = r + h$.

r = ground radius

h = altitude of the balloons

The intersection of these three places determines two possible positions for the balloon (cf. figure 11). The removal of doubt is accomplished, thanks to a second series of measures, at the time of the following orbit.

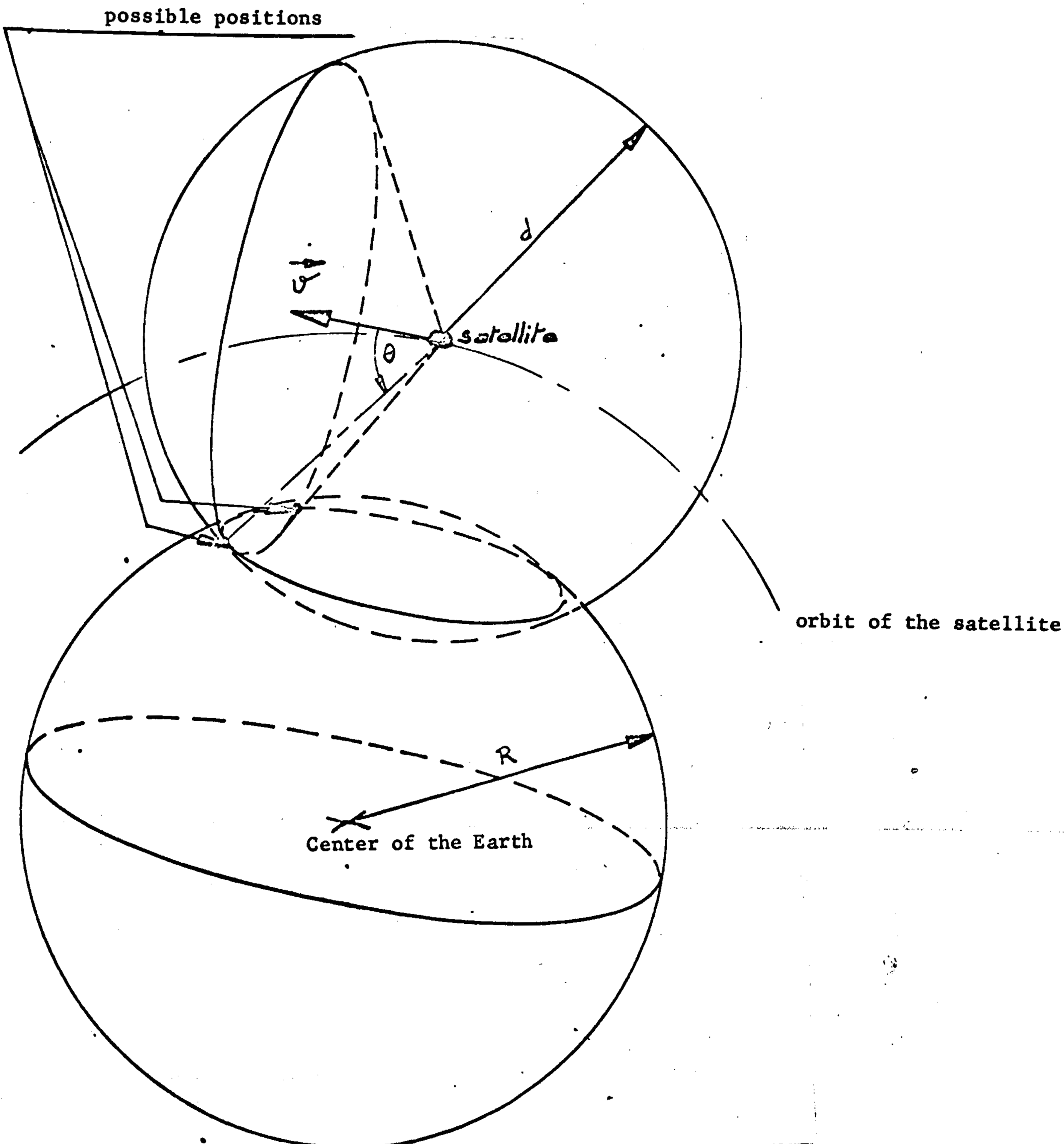
The speed vector "$\vec{V}$" of the satellite is determined by the knowledge of the ephemeris of the satellite and of the time of measure (an ultra stable oscillator on board the satellite serves as a reference to the system).

3.2. <u>Doppler measure</u> (see figure 12)

- The satellite transmits a signal of frequency f_0 (U.H.F. bearing).
- The frequency of the signal received by the balloon is

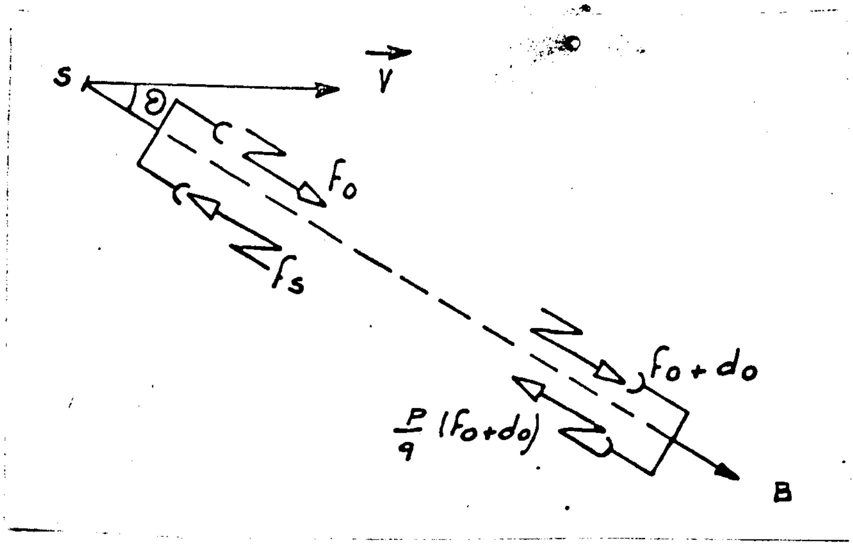
$$f_0 + d_0 \; \left(d_0 = f_0 \; \frac{|\vec{V}|}{c} \cos \theta \text{, Doppler sur } f_0\right)$$

- The balloon sends back the signal after changing coherent frequency (multiplication of the frequency received by $\frac{p}{q}$).



Principle of localization

Figure 11



$\frac{P}{Q}$ multiplication of frequency accomplished by the balloon answerer

S position of the satellite

•B position of the balloon

$\vec{V}$ vector speed of the satellite

θ $(\vec{V}, \vec{SB})$

Doppler measure Figure 12

- The satellite therefore receives a frequency signal

$$> f_S = \frac{p}{q}(f_0 + d_0) + d_i \left[d_i = \frac{p}{q}(f_0 + d_0)\frac{|\vec{V}|}{c}\cos\Theta, \right.$$

Doppler on $\left.\frac{p}{q}(f_0 + d_0)\right]$.

On board the satellite one compares the signal received to the signal broadcast (after multiplication by $\frac{p}{q}$ of the latter); the beat frequency of these two signals is measured by a compting method. In this measure, one deduces the Doppler frequency f_D, linked to the angle Θ previously defined by the relation:

$$\boxed{\cos\Theta = \frac{c}{|\vec{V}|} \qquad \frac{f_D}{2f_i}}$$

c = quickness of the light

$|\vec{V}|$ = vector speed module of the satellite

$f_i = \frac{p}{q} f_0$

$f_D = f_S - f_i$ Doppler frequency

3.3. Principle of distance measure

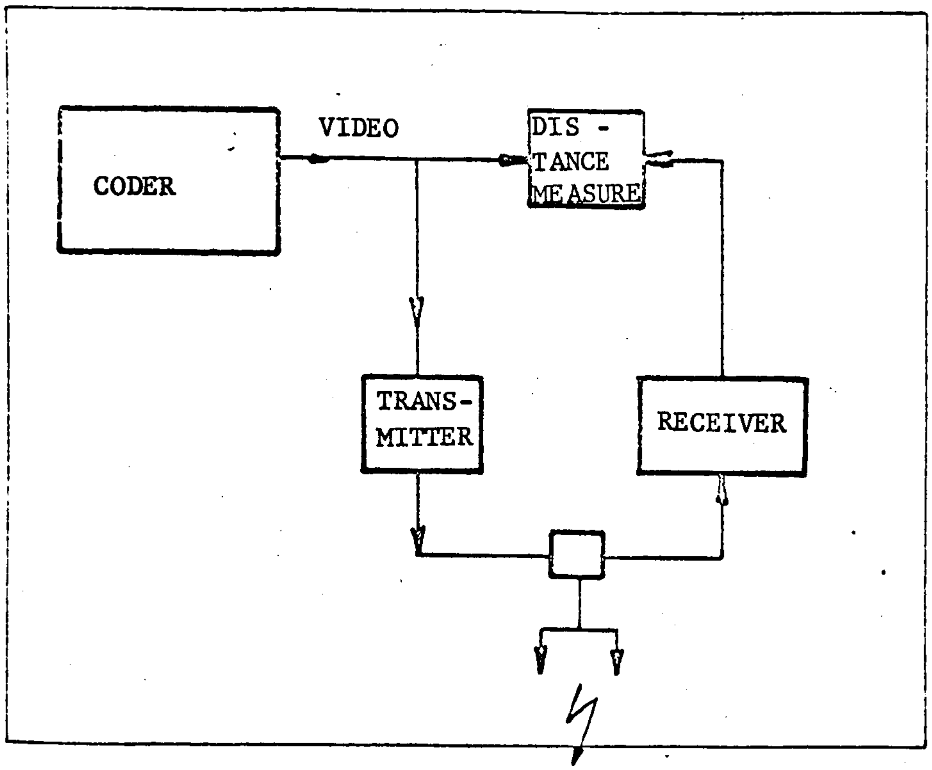
A signal modulates in phase the bearing emitted by the satellite. The balloon sends back the same signal to the satellite by modulation of the wave phase which it emits.

One measures the phase difference between the modulating signal emitted and that received (figure number 13).

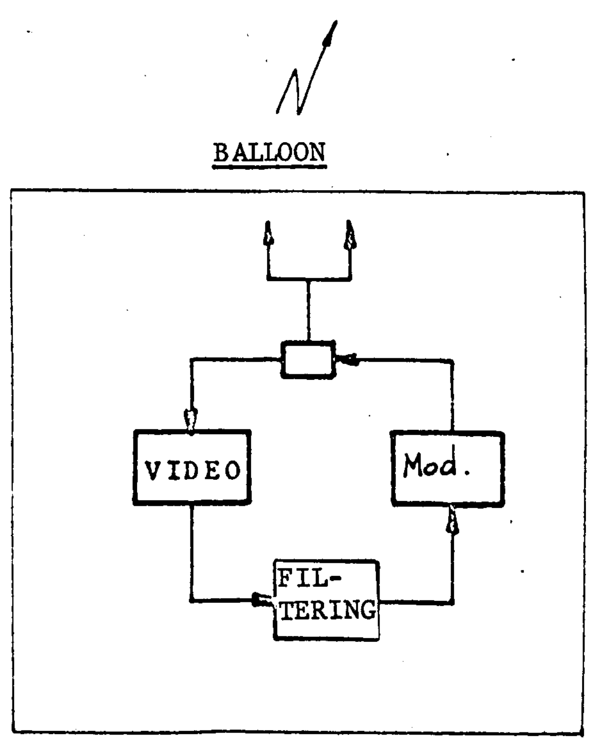
To have the precision desired, three different frequencies are necessary:

- 48 Hz, whose period corresponds to the measuring scale (3 125 km)
- 2 304 Hz, whose period corresponds to a definition of 65.1 km,
- 2 688 Hz, whose period corresponds to a definition of 55.8 km.

SATELLITE



BALLOON



These three frequencies correspond in the signal emitted to:

- 48 Hz: bit cadence
- 2 304 Hz: bit "0"
- 2 688 Hz: bit "1"

3.3.1. Description of the distance measure system

3.3.1.1. Presentation

The distance measure system is congruant to the diagram of figure number 14.

It contains three integrator phasemeters P_A, P_{ϕ_0}, P_{ϕ_1} which accomplish three phase measures.

An analogical commutator followed by an analogical-numerical converter followed by a calculator which, beginning with six components X_i, Y_i elaborated by the phasemeters, furnishes the satellite-balloon distance.

The satellite-balloon distance measure is accomplished with the help of three phase measures:

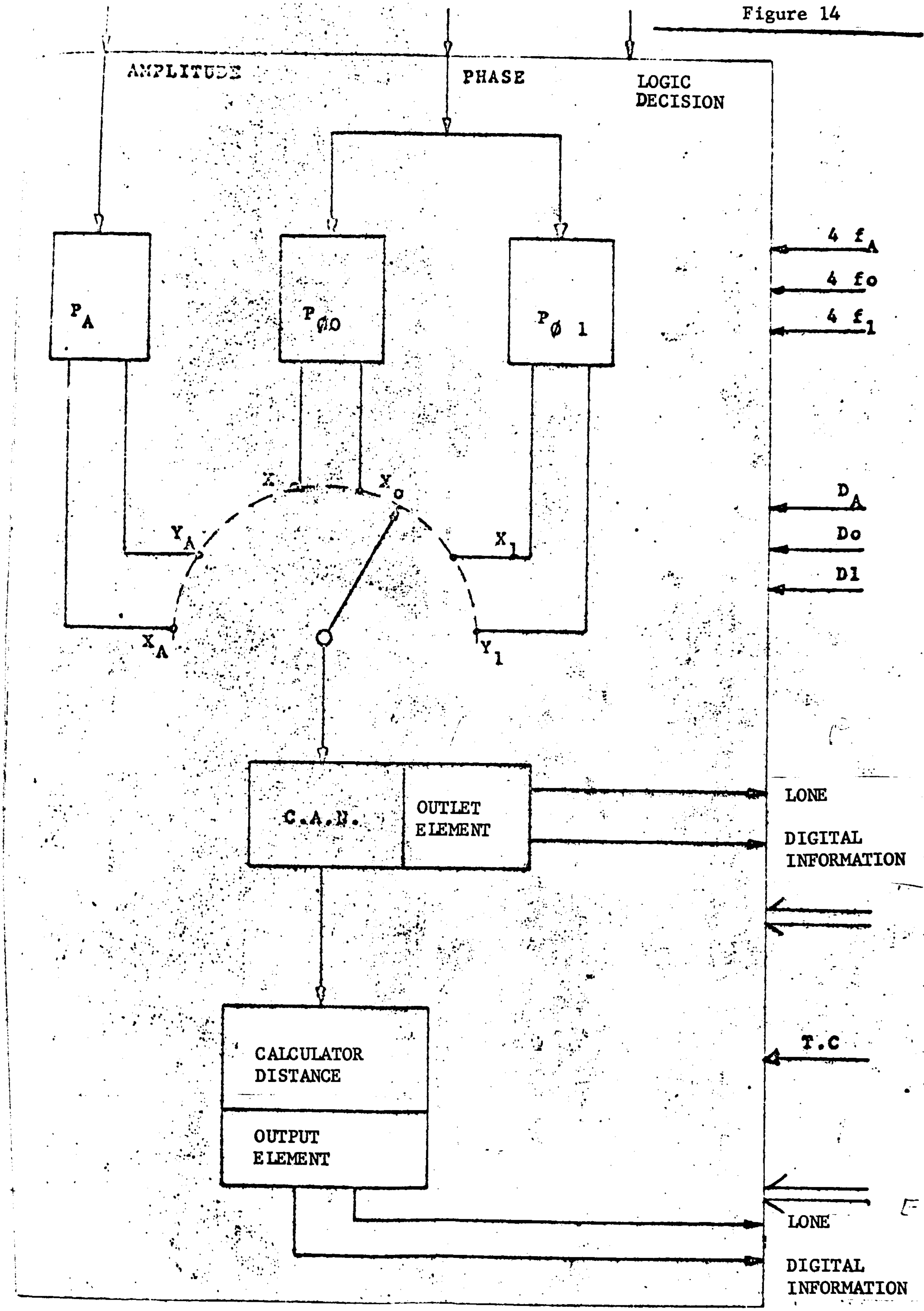
1) a phase measure on the cover signal available at the "amplitude" outlet of the coherent satellite receiver,
2) a phase measure on the video signal constituting the six "zero's",
3) a phase measure on the video signal constituting the six "ones".

The last two signals are available at the outlet "phase" of the receiver. They present themselves in the order six "zero's" then six "ones". On account of the two way propagation time of the carrying wave (variable between about 5 and 25 ms). The useful interval of the signal is limited to the duration of 4 "zero's" and four "ones".

Figure number 15 represents the utilized signals.

Signal M is the signal of satellite modulation made up of six "0", followed by six "1". The two signals R1 and R2 are two extreme cases of signal return corresponding to two balloons: the first is situated as a range limit (R1), the second is situated at the nearest (R2): vertical from the satellite.

Figure 14


AMPLITUDE
PHASE
LOGIC
DECISION
P_A
$P_{\emptyset 0}$
$P_{\emptyset 1}$
$4\ f_A$
$4\ fo$
$4\ f_1$
X_o
X_o
Y_A
X_1
X_A
Y_1
D_A
Do
D1
C.A.D.
OUTLET
ELEMENT
LONE
DIGITAL
INFORMATION
T.C
CALCULATOR
DISTANCE
OUTPUT
ELEMENT
LONE
DIGITAL
INFORMATION

48 Hz of on board satellite reference

Corresponding moments, on board satellite marked in relation to the 48 Hz of reference } Balloon farthest / nearest

A return to general zero (signal a sub group 1 U H F)

Sweeping battlement (signal b sub group 1 U H F)

Sweeping of loop controlled in phase (sub group 1 U H F)

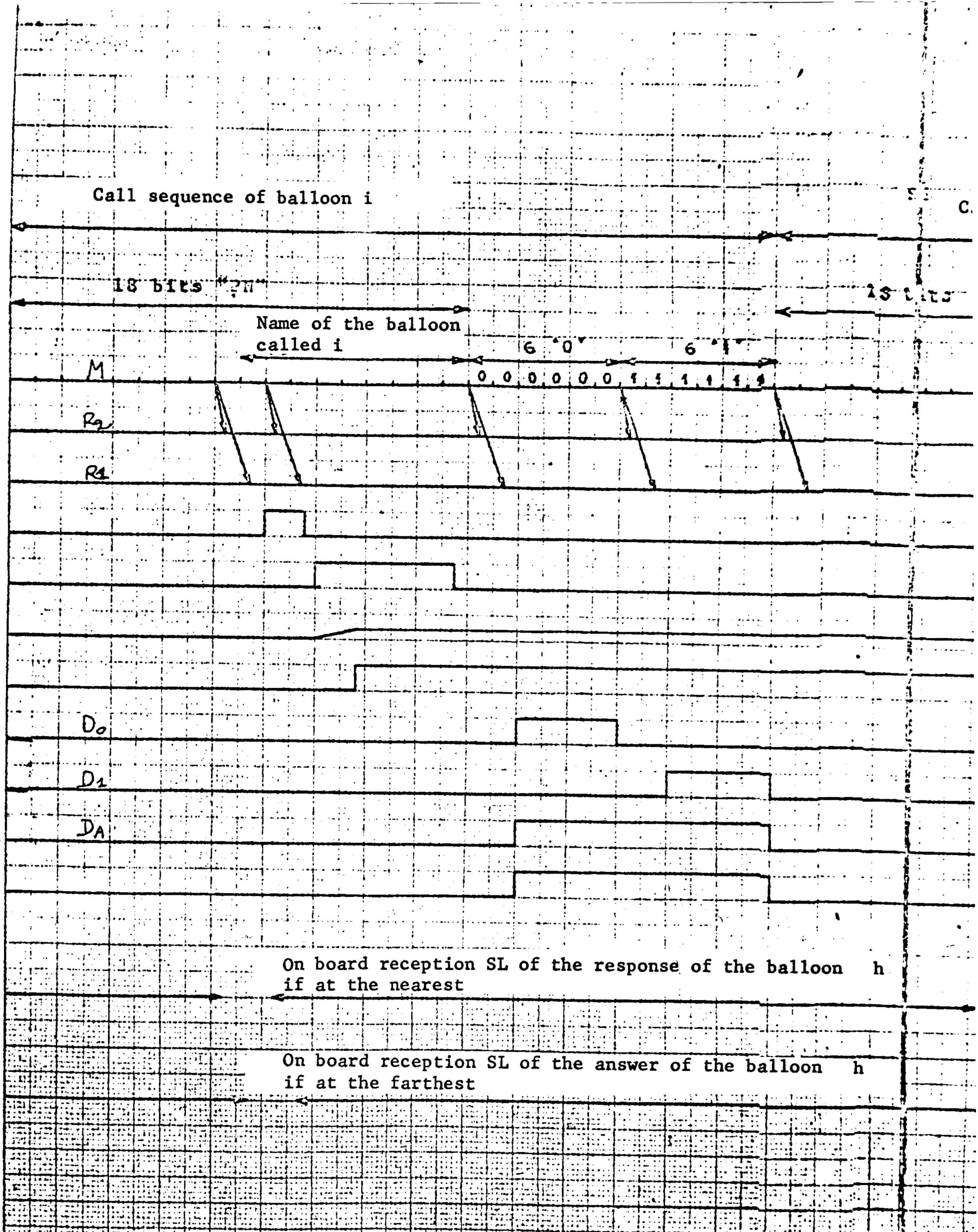
"Decision logic" signal (sub group 1 U H F)

Duration of integration of the "0" (sub group 6-1 distance measure)

Duration of integration of the "1" (sub group 6-1 distance measure)

Duration of integration of the 48 Hz (sub group 6-1 distance measure)

Duration of Doppler measure (sub group 6-3 Doppler measure)



GENERAL DIAGRAM OF TIME

Figure 15

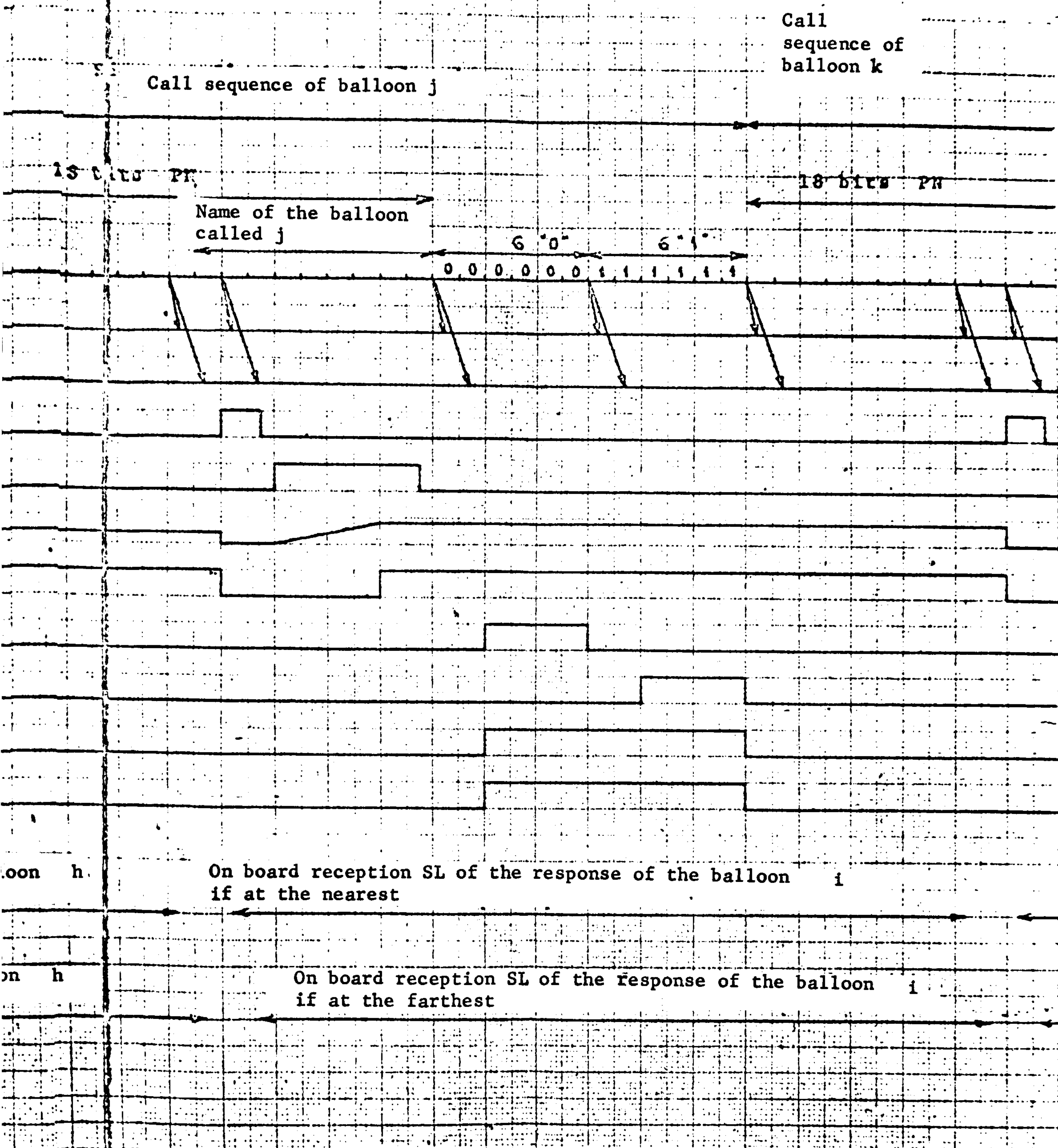


DIAGRAM OF TIME

The signal D_o represents the time of the measure of the phase on the "0".

The signal D_1 represents the time of the measure of the phase on the "1".

The signal D_A represents the time of integration on the covering of the signal.

In "amplitude" output the signal covering is present for the whole duration D_A.

In outlet "phase" the signal utilized is either the burst signal of the six "0", or the blank signal of the six "1" .

3.3.1.2. <u>Principle of measure in the output phase "amplitude"</u>

The outlet phase measurement "amplitude" on the signal covering takes place while utilizing an integrater phasemeter having as a reference the covering of the signal of modulation. The duration of integration is $D_A = 10\ U$ where U is the bit duration.

$$U = \frac{1}{48}\ s$$

$$D_A = \frac{10^4}{38}\ ms \simeq 208.33\ ms$$

3.3.1.3. <u>Principle of phase measure in outlet "phase"</u>

For the duration of the four "0", the video signal delivered on the outlet "phase" of the receiver is applied to the input of an integrator phasemeter whose reference is a permanent sinusoid for the duration D_o.

Likewise for the four "1".

The duration of integration for the two signals are:

$$D = 4\,U = \frac{4\,000}{48}\ \text{ms}$$

or: $D = 83{,}33\ldots$ ms.

3.3.1.4. Type variation on the phase measured in "amplitude" outlet

$$\sigma_{\theta_A} = \frac{1}{\sqrt{2\left(\frac{P}{No}\right)_A D_A}}$$

$\left(\frac{P}{No}\right)_A$ is the relationship $\frac{\text{signal power}}{\text{spectral density of sound}}$ at the input of the phasemeter.

For an index of modulation of $\frac{\pi}{4}$

$$\left(\frac{P}{No}\right)_A = \left(\frac{P}{No}\right)_e - (16{,}7 + 1) - L_A$$

(16.7 + 1) represents the losses of modulation

L_A is a coefficient of attenuation which realizes the the fact that the signal which modulates the balloon is not in signal ratio to infinite sound.

In EOLE case, this coefficient has been measured, it is worth between 2 and 3 dB. Consequently one will take

$$\boxed{\left(\frac{P}{No}\right)_A = \left(\frac{P}{No}\right)_e - 20\ \text{dB}}$$

The relative error on the distance is:

$$\frac{\sigma d_A}{D_A} = \frac{\sigma_\Theta}{2\pi}_A = \frac{1}{2\pi} \qquad \frac{1}{\sqrt{2\left(\frac{P}{No}\right)_A D_A}}$$

The curve in figure number 16 $\left(\frac{\sigma_\theta}{2\pi}\right)_A$ as a function of $\left(\frac{P}{No}\right)_e$ for D = 208.33 ms.

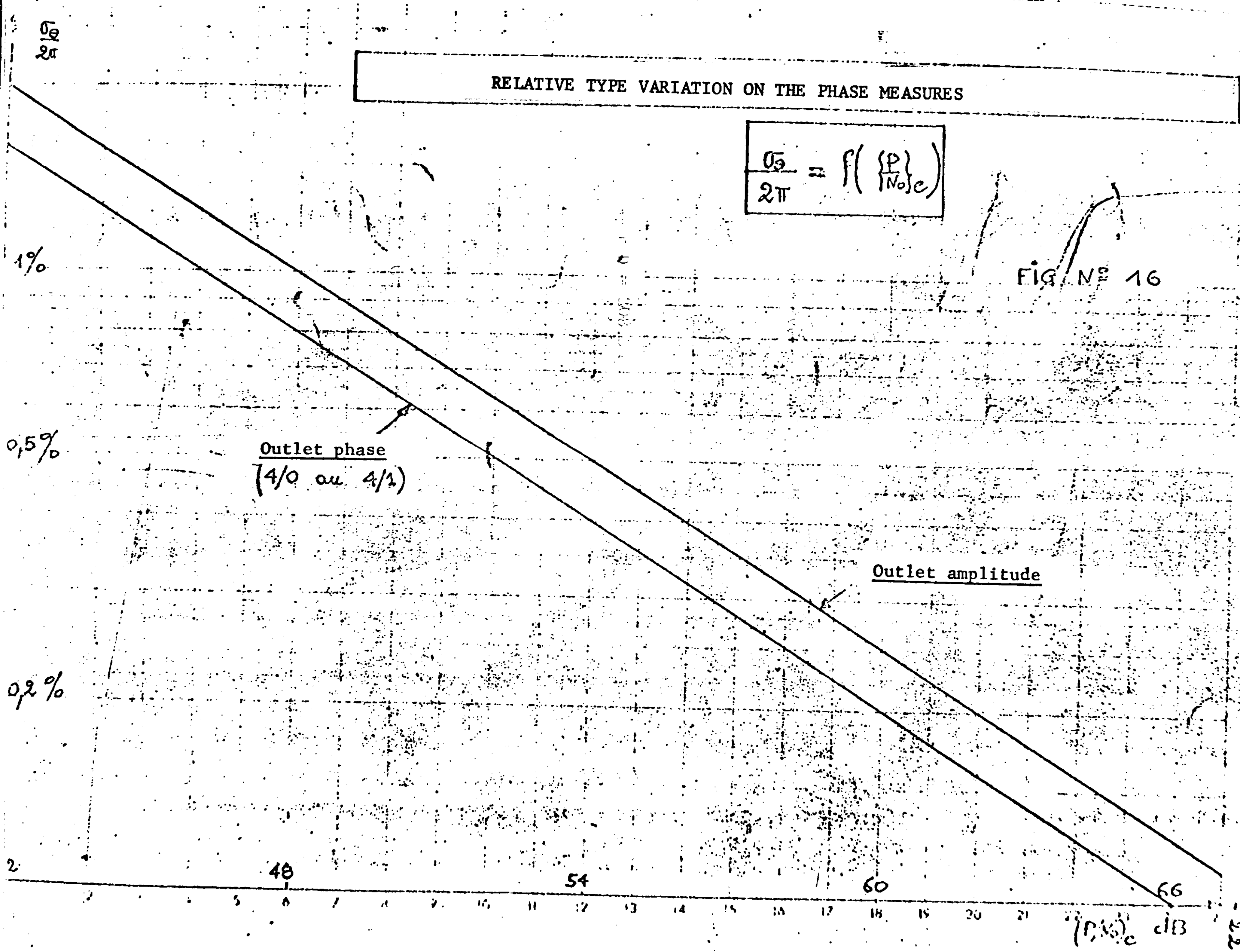
3.3.1.5. <u>Variation type on the phase measured in output "phase"</u>

The signal is present only for the duration $\frac{D}{2}$ while the integrated sound is present during D.

As a result:

$$\sigma_{\theta_\phi} = \frac{1}{\sqrt{\frac{1}{2}\left(\frac{P}{No}\right)_\phi D_\phi}}$$

$\left(\frac{P}{No}\right)_\phi$ is the relationship $\dfrac{\text{signal power}}{\text{spectral density of sound}}$ at the input of the video phasemeters.



RELATIVE TYPE VARIATION ON THE PHASE MEASURES
$\frac{\sigma_\theta}{2\pi} = f\left(\left(\frac{P}{N_0}\right)_c\right)$
$\frac{\sigma_\theta}{2\pi}$
1%
0,5%
0,2%
Outlet phase
(4/0 au 4/1)
Outlet amplitude
48
54
60
66
$(P/N_0)_c$ dB

FIG Nº 16

For an index of modulation $\frac{\pi}{4}$

$$\left(\frac{P}{No}\right)_{\phi} = \left(\frac{P}{No}\right)_{\theta} - (3,5 + 4,5)$$

3.5 dB of loss is attributed to the modulation

4.5 dB represents the influx of sound superposed on the balloon modulation, which is an experimental result.

One will take in what follows:

$$\boxed{\left(\frac{P}{No}\right)_{\phi} = \left(\frac{P}{No}\right)_{\theta} - 8 \text{ dB}}$$

The relative error of phase (or of distance) is thus:

$$\left(\frac{\sigma_{\theta}}{2\pi}\right)_{\phi} = \frac{\sigma_d}{D_{\phi}} = \frac{1}{2\pi} \frac{1}{\sqrt{\frac{1}{2}\left(\frac{P}{No}\right)_{\phi} D_{\phi}}}$$

The curve of figure number 16 represents $\left(\frac{\sigma_{\theta}}{2\pi}\right)_{\phi}$ as a function of $\left(\frac{P}{No}\right)_{\theta}$

for $D = 83,33$ ms.

3.3.1.6. Performances

1. Values of utilized frequencies

Beginning from paragraph 3.3.1. and applying the results of paragraph VI of note 92/EOLE S, the frequencies finally retained are:

f_A = 48 Hz, which involves a total distance scale of 3.125 km.

$$\begin{cases} f_o = 2\ 304 \text{ Hz} \\ f_1 = 2\ 688 \text{ Hz} \end{cases} \quad \text{or} \quad \begin{cases} D_o = 65,1 \text{ km} \\ D_1 = 55,8 \text{ km} \end{cases}$$

$$\frac{f_o}{f_1} = \frac{2\ 304}{2\ 688} = \frac{384 \ .\ 6}{384 \ .\ 7} = \frac{6}{7}$$

The intermediary phere determined by the combination of f_o and f_1 has for a radius:

$$d \quad D_i = \frac{300\,000}{2 \cdot 384} = 390{,}625 \text{ km}$$

A burst of signal modulation contains either 24 periods of the signal at f_o frequency, or 28 periods of the signal at f_1 frequency.

2. Removal of doubt

The bases of calculation which have served to determine the frequencies are such that the removal of doubt is limited in range accomplished at best as 3σ (99.7% of the cases are correctly treated).

However a restriction exists in the present case due to the fact that the measures on f_o and f_1 are not simultaneous.

Consequently the corresponding "distance" spheres are not concentric (see figure number 17). In order to realize this fact, it is necessary to utilize the knowledge of angle θ furnished by the Doppler measure. However this relatively complex operation renders the two measures interdependent, which is not desirable. It seems preferable to resolve the problem in the following way:

a) Carry out the determination of the coefficients m_1 and m_2, as if the $\overrightarrow{0_oB}$ and $\overrightarrow{0_1B}$ vectors were colinear. But the correct condition of removal of doubt is written then:

$$\left| d_1 + m_1 D_1 - d_2 + m_2 D_2 \right| < \frac{\Delta}{2} - \left| O_o O_1 \right| \quad \cos \theta$$

θ varies from $+27^o$ to -27^o (see figures number 18 and 19). The probability of accomplishing an incorrect removal of doubt can be allowed for as follows:

$$P_r \left(x_1 + x_2 \geqq \frac{\Delta}{2} - 0{,}8 \text{ km} \right)$$

In the preceeding conditions of signal relationship to noise this relation becomes an equality at 3σ, that is to say that the probability of incorrect removal of doubt is about 3 cases out of 1000.

b) Once m_1 and m_2 are determined, calculate

$$d_i = \frac{d_1 + m_1 D_1 + d_2 + m_2 D_2}{2}$$

and assume this result at the point O_A, middle of the segment O_oO_1.

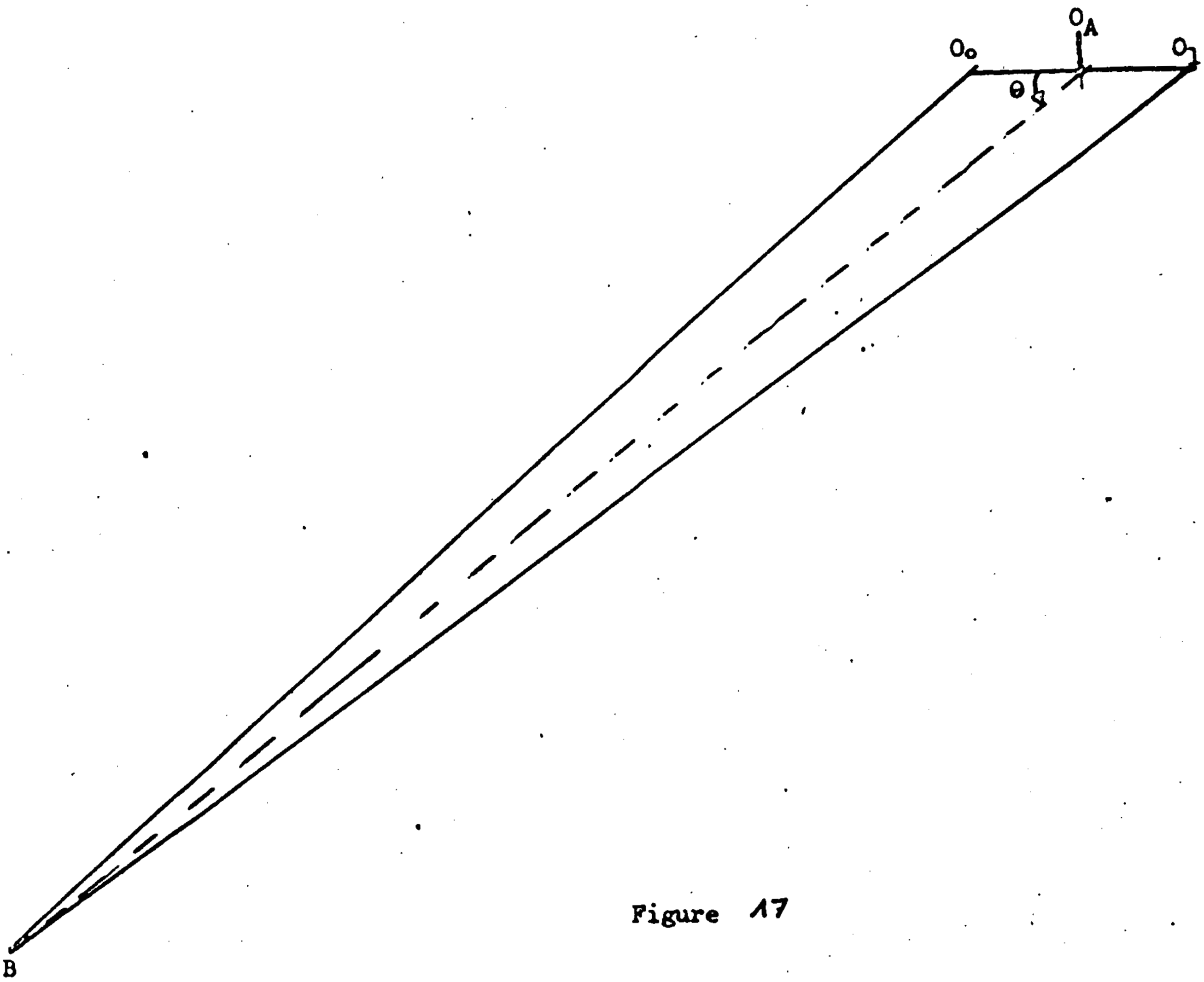


Figure 17

Centre National d'Etudes Spatiales	Figure 18	-26-
	REMOVAL OF DOUBT INTERMEDIARY SPHERE	

$f_0 = 2304$ Hz ; $f_1 = 2688$ Hz

$D_0 \# 65{,}1$ km

$D_1 \# 55{,}8$ km

$D_0 - D_1 = \Delta \# 09{,}3$ km

Minimal values for σ_0, σ_1

$\sigma_0 = \frac{1{,}6}{100} \times 65{,}1 \# 1$ km

$\sigma_1 = \frac{1{,}6}{100} \times 55{,}8 \# 0{,}9$ km

$\sigma_\Delta = \sqrt{\sigma_0^2 + \sigma_1^2} = 1{,}35$ km

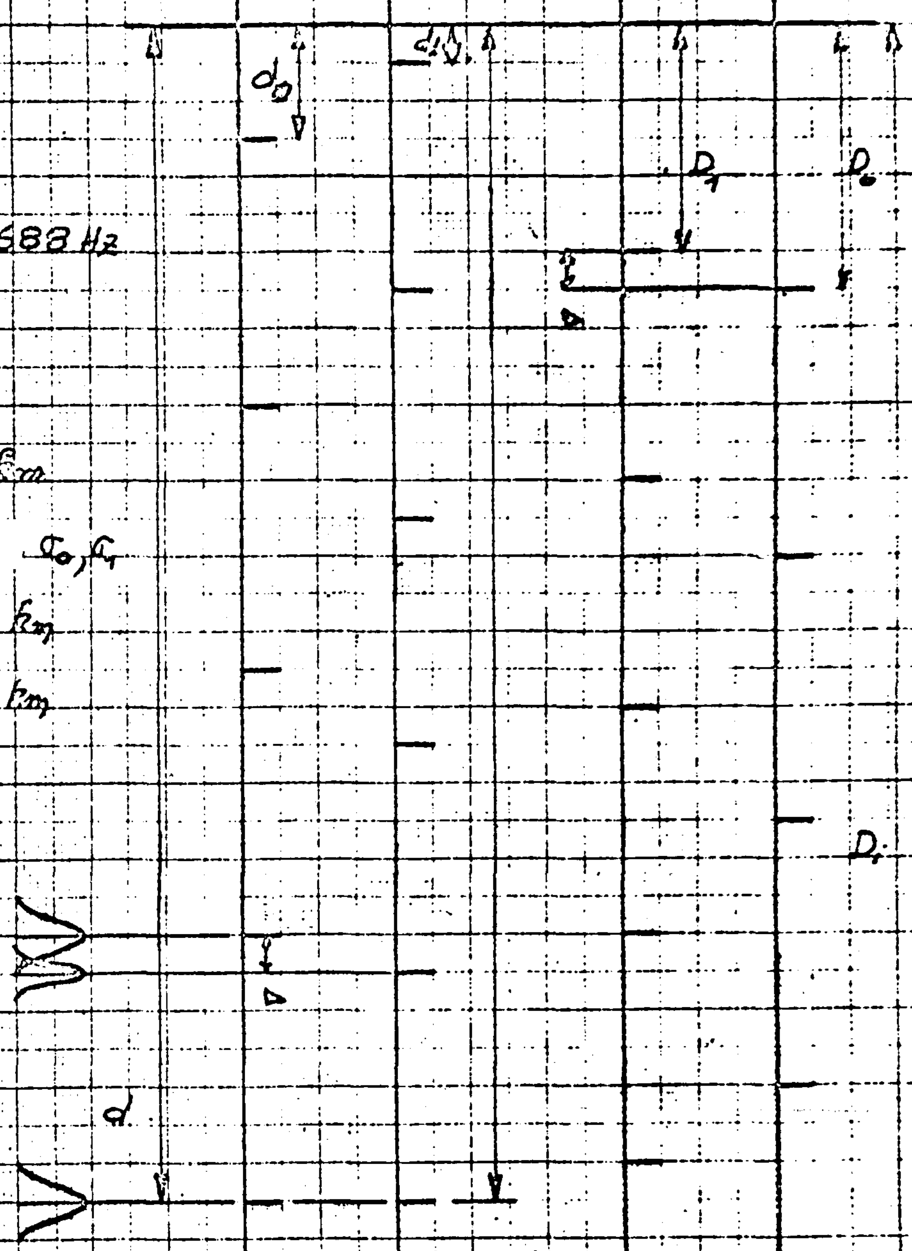
Number of σ of protection on the removal of doubt Δ

$n_\sigma = \frac{\Delta/2}{1{,}35} = \frac{9{,}3}{2 \times 1{,}35}$

$n_\sigma = 3{,}44$

$f_i = \frac{f_0}{6} = \frac{f_1}{7} = 384$ Hz

$D_i \# 390{,}6$ km



Centre National d'Etudes Spatiales	Figure 19 REMOVAL OF DOUBT - TRUE DISTANCE	27

$f_r = 48\ Hz$

$D_A = 3125\ km$

$D_r = 590{,}6\ km$

$\sigma_A = \frac{2}{100} \times 3125 = 62{,}5\ km$

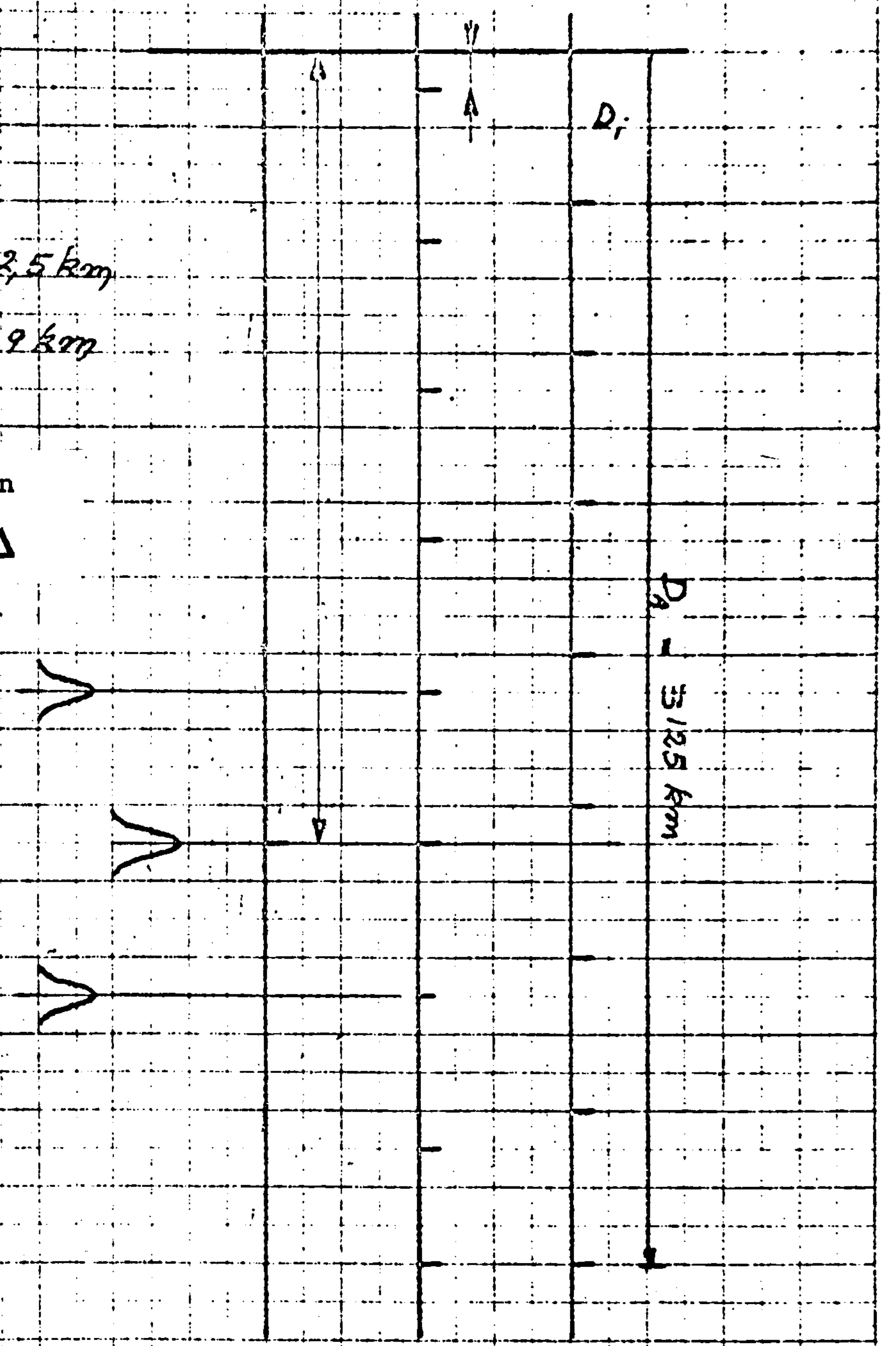
$\sigma_r' = \frac{1{,}6}{100} \times 55{,}9 \neq 0{,}9\ km$

$\sigma_A \gg \sigma_r'$

Number of σ of protection

on the removal of doubt Δ

$n_\sigma = \frac{[illegible]}{2 \times 62{,}5} = 3{,}1$



O_AB being much greater than O_oO_1,d_i thus calculated is at some meters near the distance O_AB. Moreover this intermediary sphere is cocentric with the sphere defined by the measure on the "amplitude" signal.

4 - METEOROLOGICAL INFORMATION

Four informations are considered:

- temperature,
- pressure,
- excess pressure of the covering,
- a fourth parameter not actually defined.

The following solution is retained:

4.1. Signal sent by the balloons

The four captors furnish four periodic signals F_a, F_b, F_c, F_d whose frequency is joined to the value of the measured parameter. These signals are multiplexed in time. The message obtained modulates the bearing phase sent by the balloon to the satellite.

4.2. Principle of decommutation on board the satellite

A loop subdued in phase, swept in frequency in order to diminish the landing times,is locked successively on each one of the four frequencies. By four successive countings of the oscillator frequency of the loop one finds again the frequencies of the signals broadcast.

5 - GENERAL FUNCTIONING OF THE INFORMATION AND LOCALIZATION SYSTEM - SATELLITE-BALLOON CONNECTION AND RETURN

The two way satellite-balloon connection should be considered at the two levels:

- bearing,
- modulation.

5.1. Bearing connection

The bearing connection, in which, with a near multiplicative factor, the balloon sends back to the satellite a coherent signal of the wave received, which permits the Doppler measure.

When a balloon comes within sight, its U. H. F. receiver box in phase. By a means which will be described later it only causes its transmitter to operate when it receives information indicating to it that it is called for. It sends back then to the satellite the bearing received at a change of near frequency.

On board the satellite, a receiver receives this bearing, locks itself in phase and from that time on, the Doppler measure is made.

Important parameters:

f_{SL-BL}	$\simeq$	460 MHz
f_{BL-SL}	$\simeq$	400 MHz
t_{accMax}	$\simeq$	100 ms

where t_{accMax} is the maximal landing time of the satellite receiver.

5.2. Connection modulation

This connection is accomplished by modulation of phase of the bearing in two ways:

5.2.1. Satellite-balloon connection

Its aim is double:

1. To send to the balloons information indicating which balloon is called for.
2. To send to the balloons signals which will be sent back directly to the satellite permitting distance measure.

5.2.2. Balloon-satellite connection

It aim is double:

1. To send back the signals received to the satellite in a coherent way, permitting distance measure.
2. To send to the satellite the information from the four meteorological captors placed on board the balloon.

A supplementary characteristic of balloon-satellite connection is:

during the 100 ms of balloon emission corresponding to the landing time of the satellite receiver, the bearing is pure, exempt from all modulation.

Important parameters:

frequencies necessary to distance measure	$f = 48$ Hz $f_0 = 2\ 304$ Hz $f_1 = 2\ 688$ Hz
index of modulation	$\frac{\pi}{4}$ rd
level of signal received	-130 dBm

5.3. Sequence of satellite-balloon functioning

5.3.1. System of transmission of satellite-balloon information

The modulating signal has the appearance described in figure number 20.

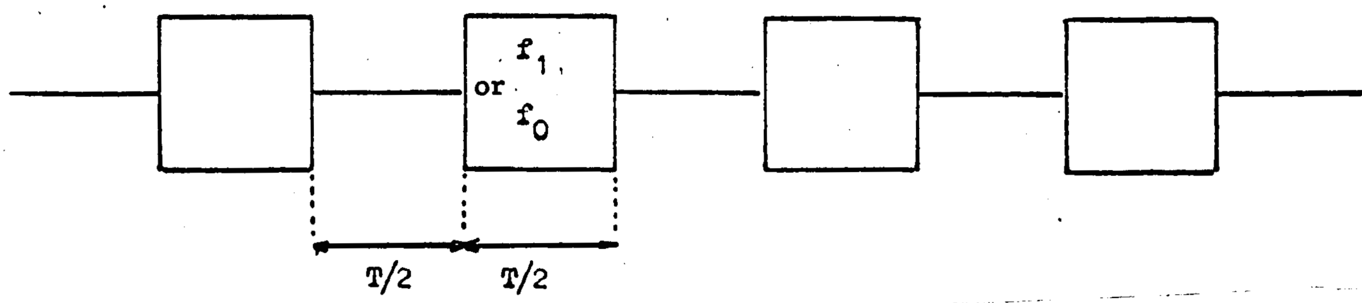


Figure number 20

The frequency during the "burst" serves on one hand as the distance measure, on the other hand to characterize the bits "1" or "0" serving as address for the balloons.

5.4. Sequence of balloon-satellite functioning

A balloon coming into view from the satellite locks its receiver, then its decommutation system. At a certain moment, it recognizes its address. The balloon should emit the following sequence:

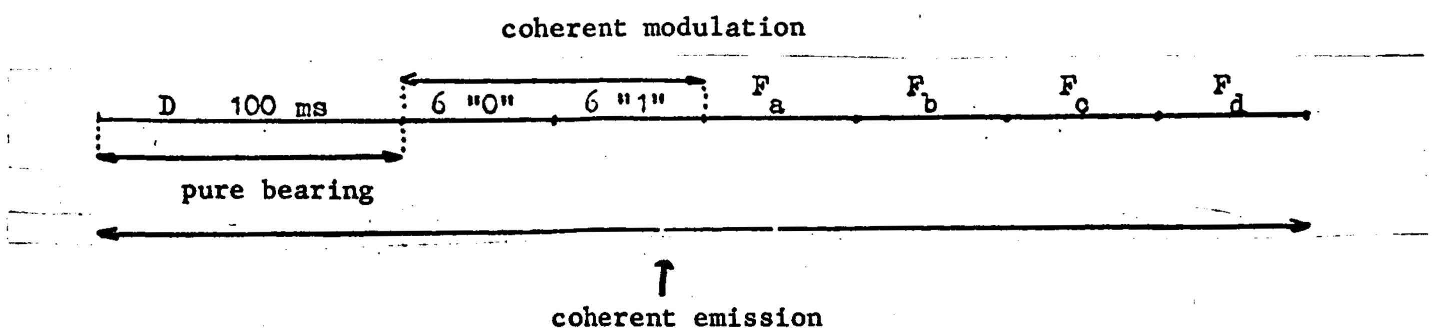


Figure number 21 Sequence emitted by the balloon called for

The balloon transmitter is begun at the moment it emits at the minimum 100 ms of pure bearing. The end of this pure emission should coincide with the moment of reception of the six "0", six "1", originating from the satellite.

The diagram of the times of the system is represented in figure number 22.

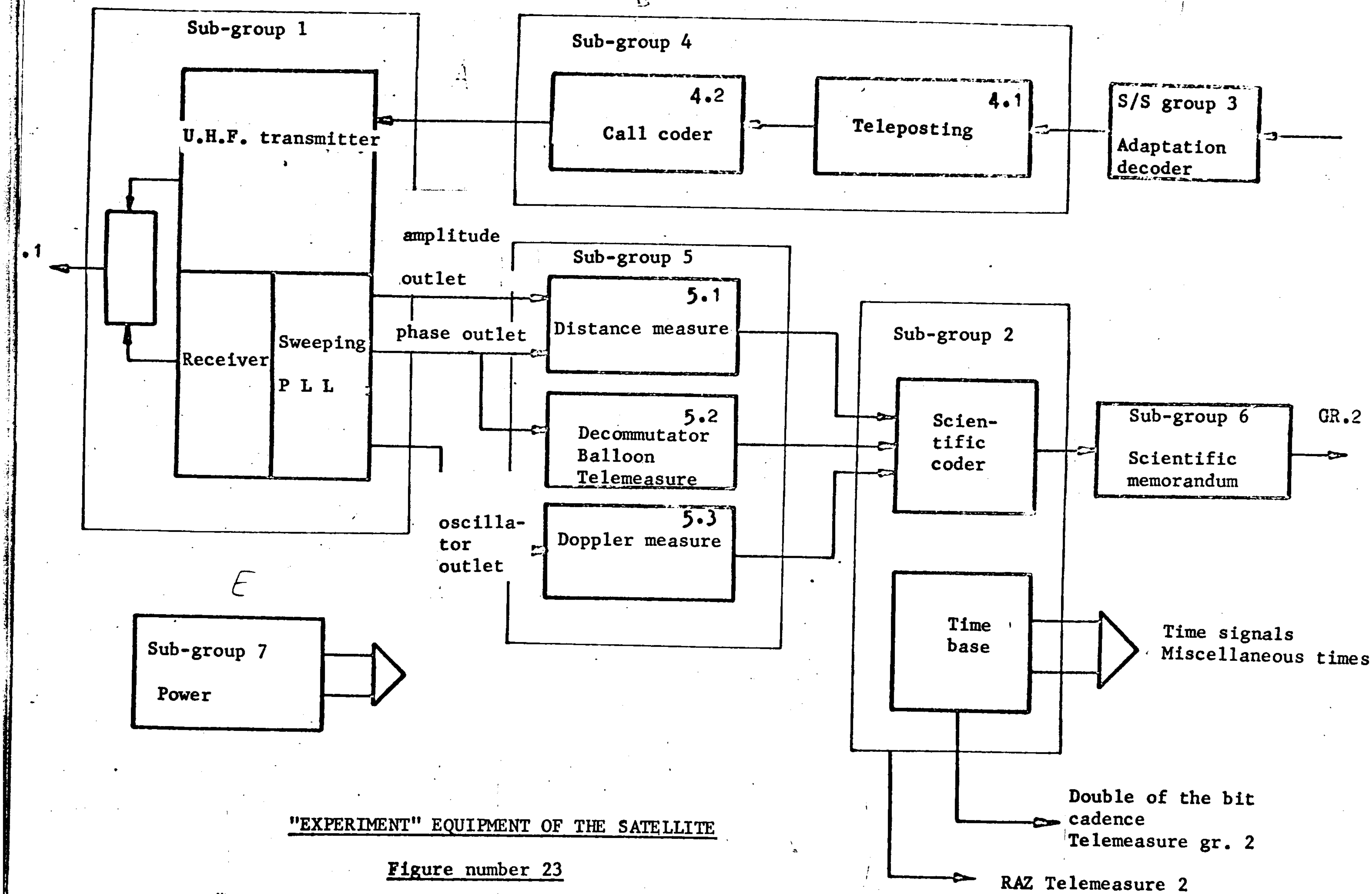
Having received 18 "PN" bits, six "0", six "1" and having verified that it is called for, the balloon allows 10 bits to pass, starts its non-modulated transmitter for 8 bit durations; at this moment, it begins to receive six "0", then six "1", which it sends back immediately - then it sends successively F_a, F_b, F_c, F_d, each one lasting two bit durations. Then it ceases all broadcast.

6 - SCIENTIFIC MEMORANDUM

The information

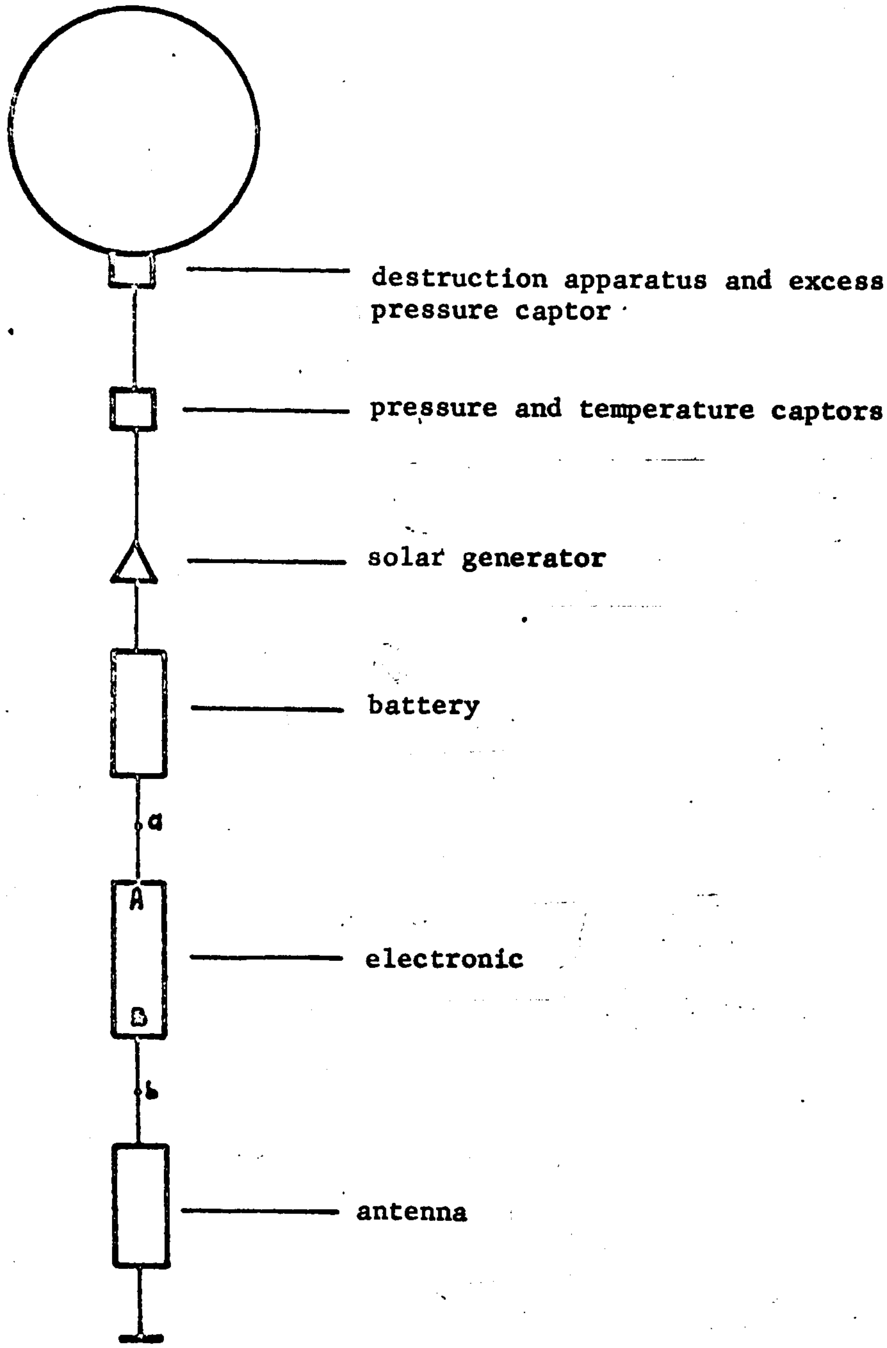
θ	Doppler
d	Distance
F_a à F_d	Meteorological parameters
N_i	Name of the balloon
satellite time	

corresponding to the connection with a balloon are stored in a memorandum capable of storing information corresponding to about 1000 answers.



"EXPERIMENT" EQUIPMENT OF THE SATELLITE

Figure number 23



CONFIGURATION OF THE NACELLE

Figure number 24

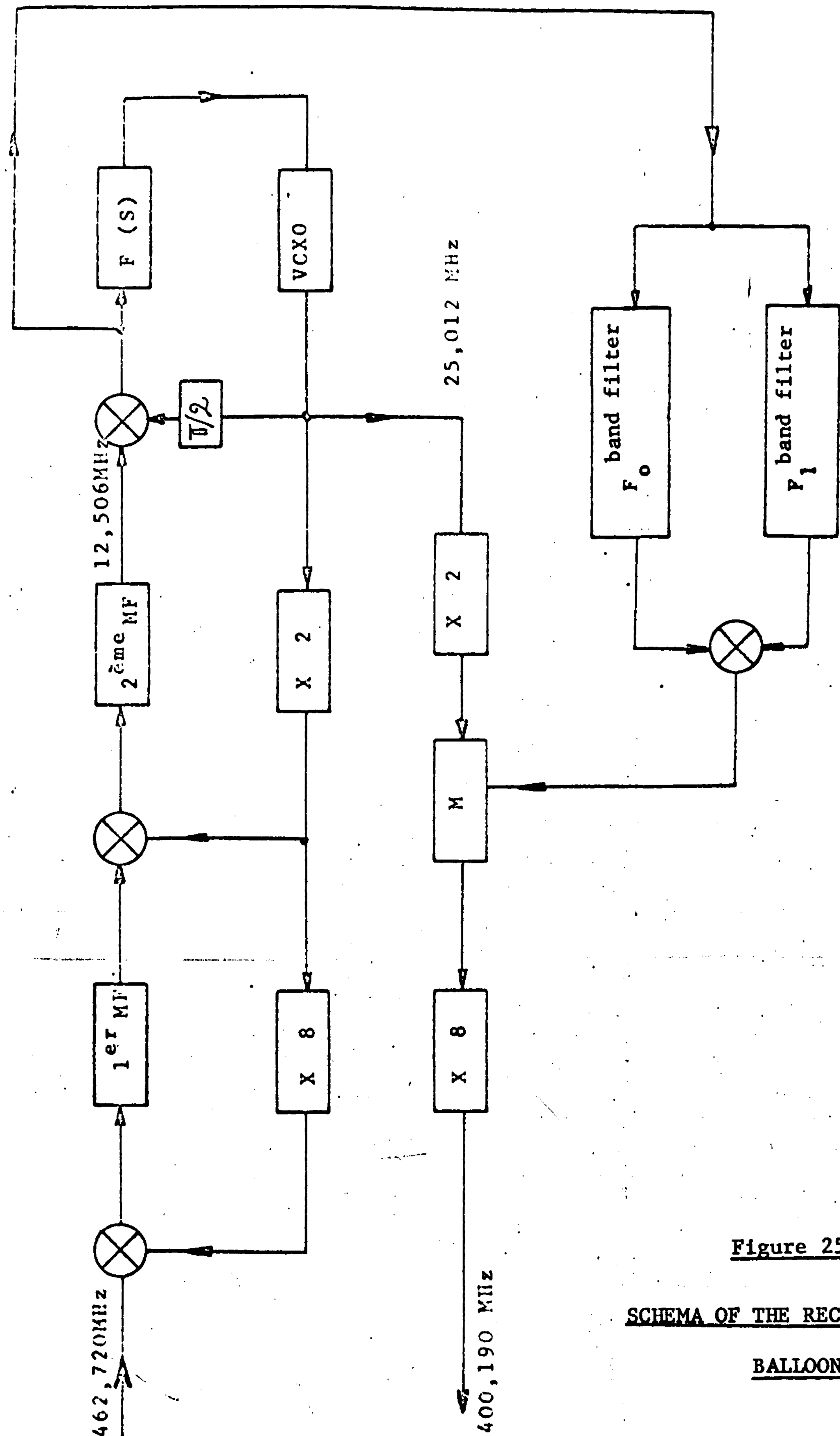


Figure 25

SCHEMA OF THE RECEIVER OF THE BALLOON

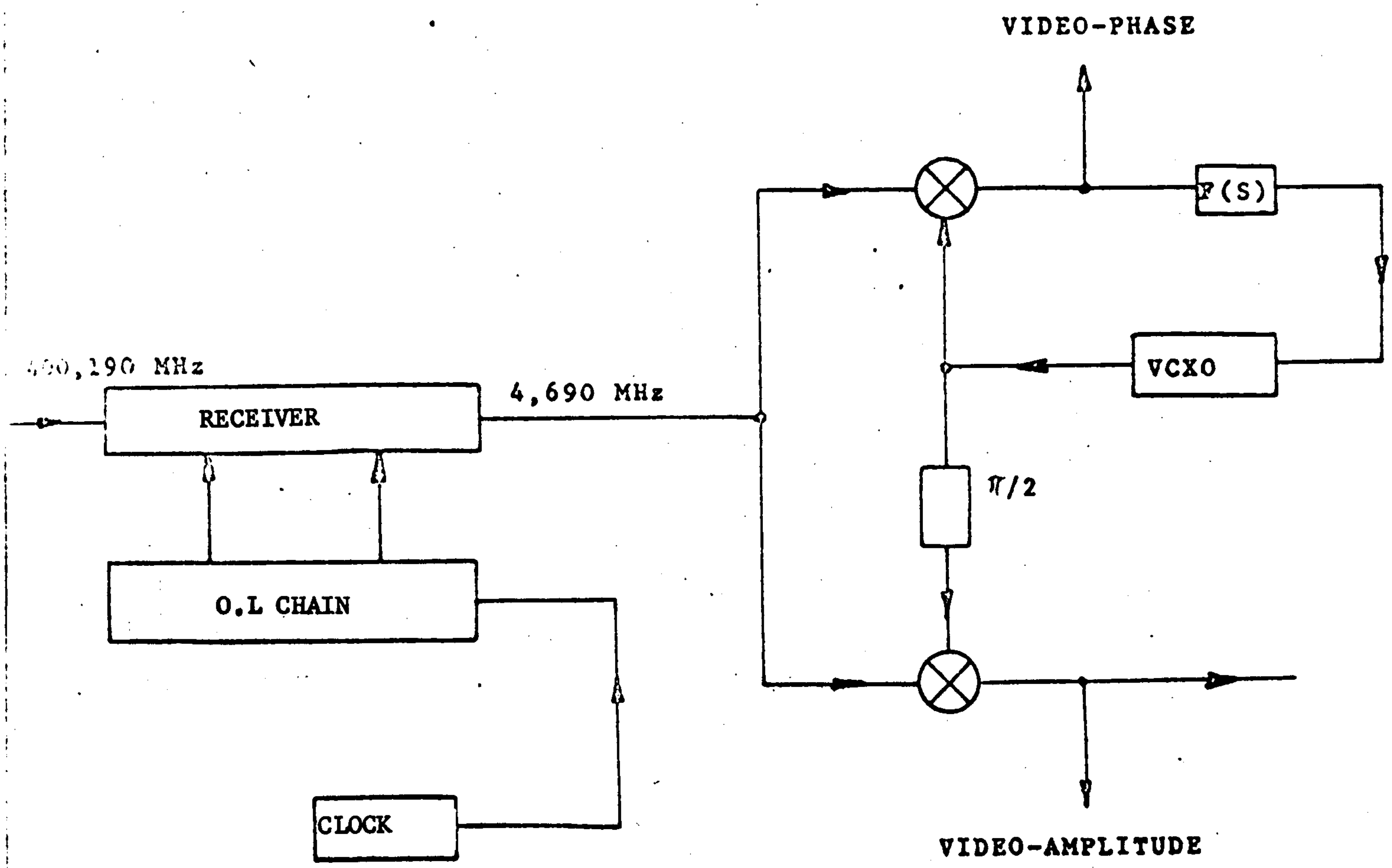


Figure 26

SCHEMA OF THE SATELLITE RECEIVER

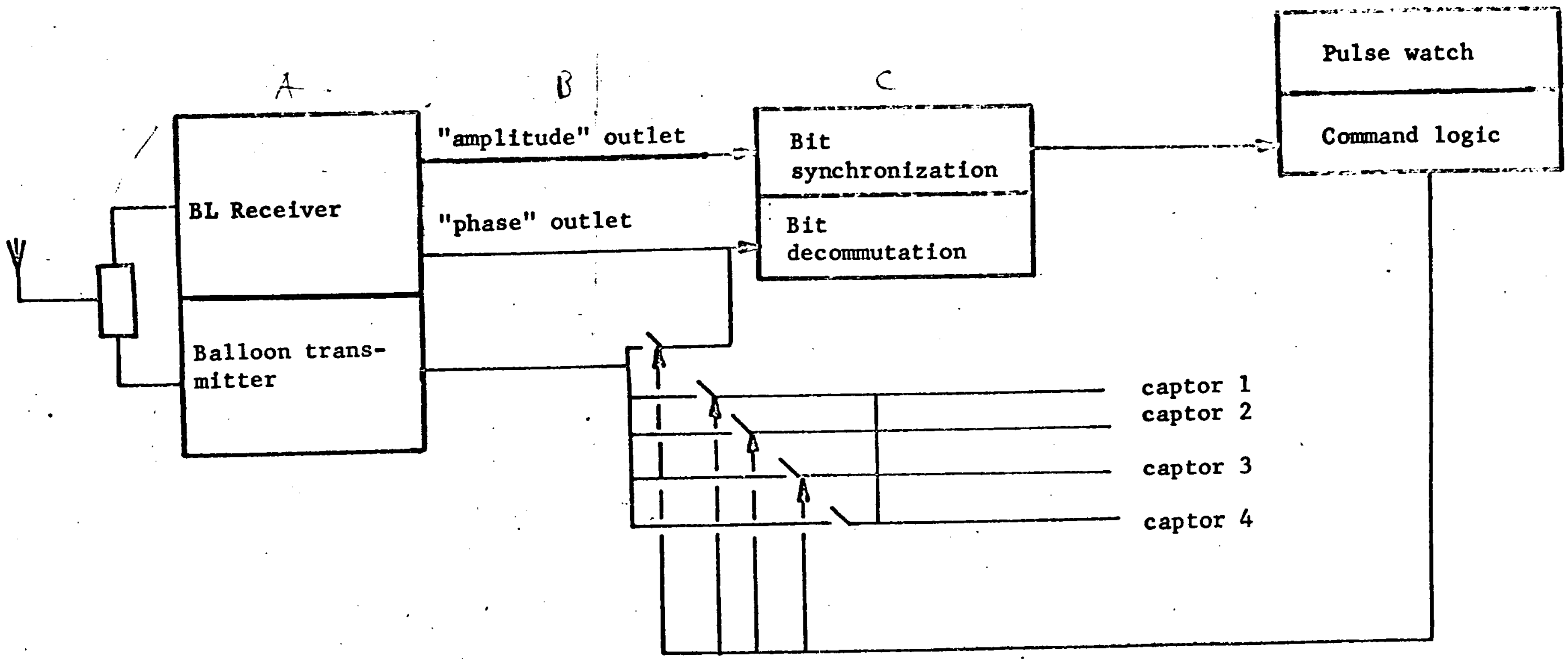


Figure number 27

BALLOON EQUIPMENT